
Near-Term Solutions for Mitigation of Industrial Sector Carbon Dioxide Emissions in California

**California Air Resources Board
International Symposium on Near-Term Solutions for Climate
Change Mitigation in California**

March 5, 2007

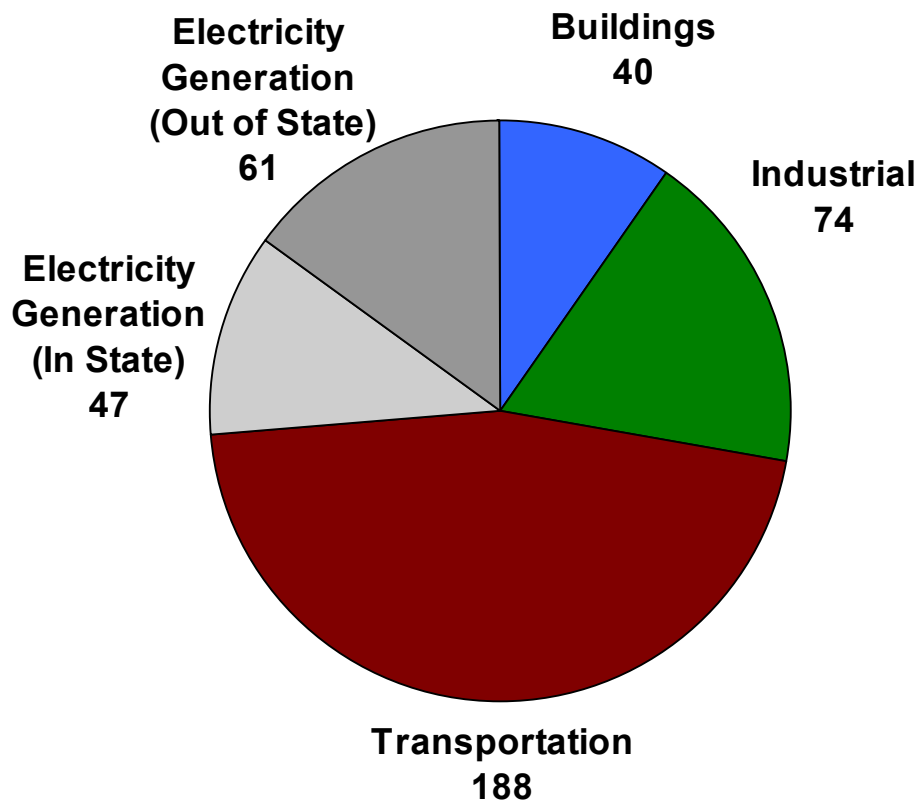
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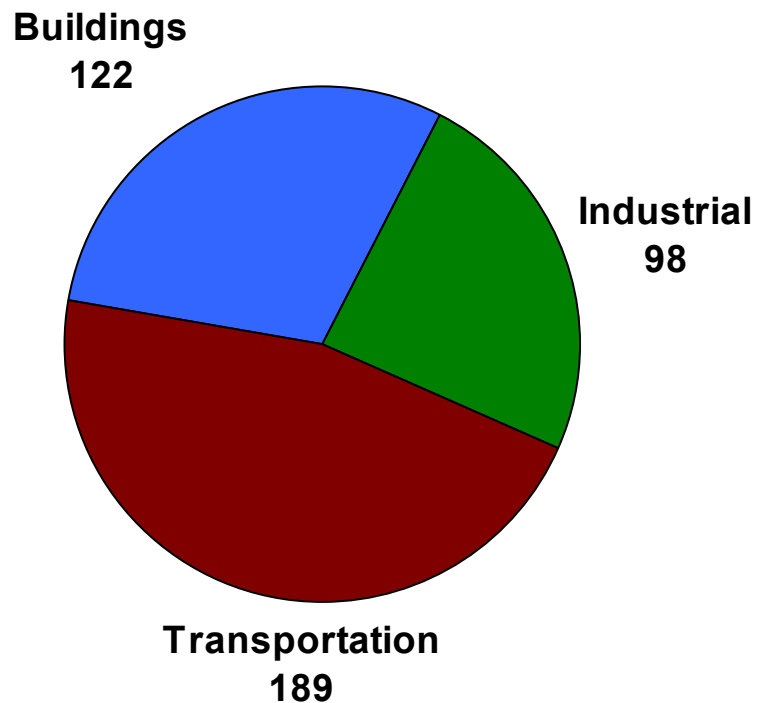
- U.S. Department of Energy research laboratory
- Managed by the University of California
- ~ 4000 employees
- 11 Nobel Laureates
- Environmental Energy Technologies Division conducts research and development leading to better energy technologies that reduce adverse energy-related environmental impacts
- Energy Analysis Department focuses on analysis of energy use and GHG emissions trends, mitigation options, and policies from an end-use perspective



California 2004 CO2 Emissions (MtCO2)



Electricity Allocated to End-Use Sectors



Source: California Energy Commission, 2006. *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004*. Sacramento: CEC.

Note: cement process-related CO2 emissions include in industrial sector

California's Industrial Sector Energy-Related CO2 Emissions

MtCO2 (2000)

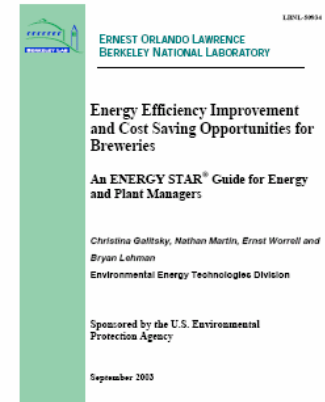
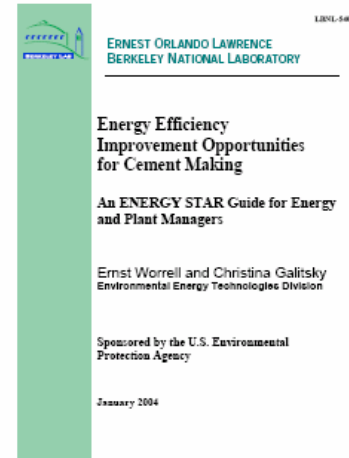
	Electricity	Natural Gas	Petroleum Products	Coal	Total
Oil Refineries	2.3	5.6	23.4	0.0	31.2
Oil and Gas Extraction	1.4	15.4	0.1	0.0	16.9
Non-specified (Industry)	0.2	0.8	5.2	1.5	7.7
Agriculture	2.3	1.0	4.1	0.0	7.4
Stone, Clay, Glass, Cement	1.2	1.7	0.8	2.9	6.6
Food Products	2.0	3.7	0.0	0.0	5.7
Chemicals and Allied Products	1.4	0.8	0.5	0.0	2.6
Metal Durables	1.8	0.8	0.0	0.0	2.6
Pulp and Paper	0.9	1.6	0.0	0.0	2.5
Electric and Electronic Equipment	2.0	0.3	0.0	0.0	2.3
Primary Metals	0.8	0.9	0.0	0.0	1.7
Transportation Equipment	0.9	0.5	0.0	0.0	1.4
Plastics and Rubber	0.9	0.3	0.0	0.0	1.2
Wood and Furniture	0.6	0.3	0.0	0.0	0.9
Textiles	0.3	0.6	0.0	0.0	0.9

Murtishaw, S., De La Rue du Can, S., Price, L., Masanet, E., and Simcich, M., 2006. *CALEB: California Energy Balance Database*, Berkeley, CA: LBNL.

Energy-Efficiency Technologies and Measures for Industry

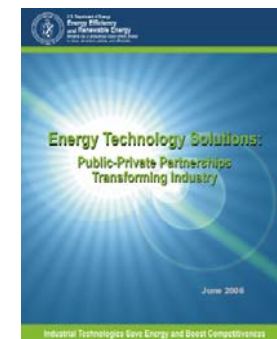
- **US EPA Energy Star for Industry Program**

- Petroleum refining: 90
- Pharmaceuticals: 102
- Food processing: 150
- Cement: 40
- Glass: 114
- Breweries: 45
- Auto assembly: 93
- Petrochemicals: 100



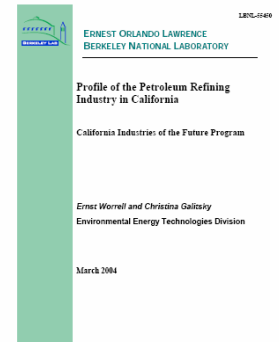
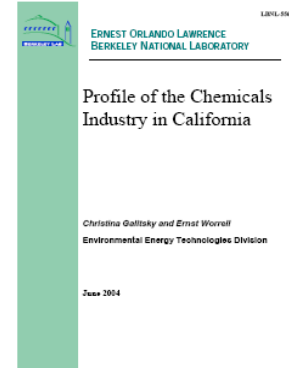
- **US DOE Industrial Technologies Program**

- ~ 90 new technologies “for today” for aluminum, chemicals, forest products, glass, metal casting, plastics, mining, petroleum refining, steel
- Energy-efficient technologies for industrial systems (motors, steam, compressed air, etc.)



Energy-Efficient Technologies for California

- **California Industries of the Future**
 - Profile of the Chemicals Industry in California
 - Profile of the Petroleum Refining Industry in California
- **Northwest Food Processors Association and California League of Food Processors**
 - Energy Portal: 70 commercially-available technologies and measures

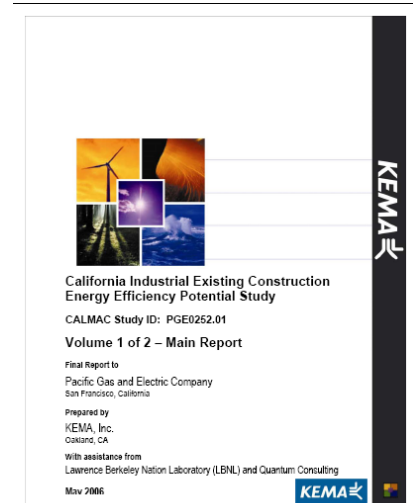


- **BEST- Winery: Benchmarking and Energy Saving Tool for Wineries in California**
 - 84 energy efficiency measures
 - 19 water efficiency measures

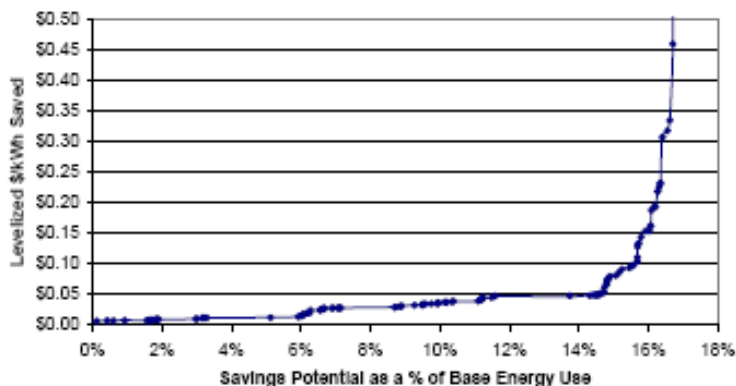
California Industrial Energy Efficiency Potential

KEMA study:

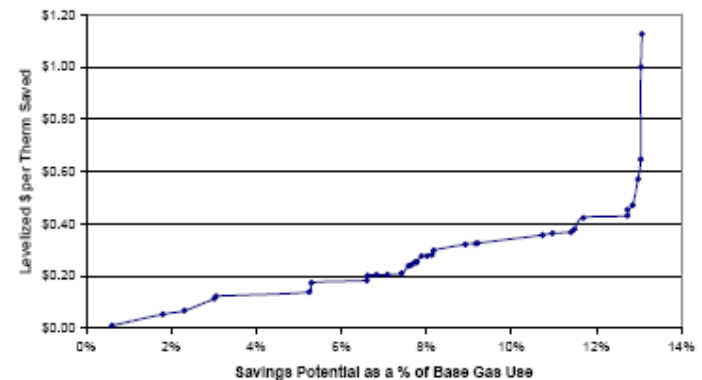
- Identified 127 electricity and 36 natural gas energy-efficiency technologies and measures for the manufacturing sector
- Economic potential of ~ 4.4 MMtCO₂e through 2016
 - ~ 2.0 MMtCO₂e from electricity
 - ~ 2.4 MMtCO₂e from natural gas
- Savings from baseline of 15% for electricity and 13% for natural gas



Industrial Electric Energy-Efficiency Supply Curve, 2005 – Energy



Industrial Natural Gas Energy-Efficiency Supply Curve, 2005



Reaching a California Industrial CO2 Emission Reduction Goal

- **Energy efficiency and energy management**
 - Natural gas and electricity
 - Oil and coal
- **Fuel switching**
 - Within fossil fuels
 - Incineration of wastes in cement kilns
- **Renewables**
 - Biomass, biogas, solar drying for food processing
 - Wind, solar to generate electricity
- **Heat and power recovery**
 - Heat recovery through process integration
 - Power recovery
 - Combined heat and power

Reaching a California Industrial CO₂ Emission Reduction Goal

- **Material efficiency**
 - Design
 - Recycling (steel, glass, plastics, paper)
 - Materials substitution (use of blast furnace slag, fly ash and geo-polymers in cement manufacturing)
- **Feedstock changes**
 - Recycled plastics
 - Biofeedstocks, non-wood fibers
- **Product change**
 - Blended cement
 - High strength glass containers
- **CO₂ sequestration**

Industrial Energy Efficiency and GHG Emissions Reduction Programs



Target-setting programs

- Industrial sector target-setting programs are common: over 20 national-level, target-based industrial sector programs identified
- Range from voluntary to mandatory
- Include targets for either industrial sub-sectors or industrial facilities
- Based on signed agreements committing upper management to reaching targets
- Some include energy or GHG taxes, some include emissions trading
- Supporting policies and programs are essential for assisting industry in reaching targets

Industrial Target-Setting

Supporting Policies and Programs

- Information on energy efficiency and GHG emissions mitigation options
- Energy audits, assessments, benchmarking
- Assistance in preparing inventories, identifying opportunities, developing energy-saving plans, energy management
- Financial assistance and incentives
- Government and public recognition
- Relief from additional regulations or exemptions from regulations
- Reduced or avoided energy/GHG taxes
- Penalties for non-compliance: stricter environmental permitting, penalty fees, energy or CO₂ tax
- Emissions trading



Industrial Target-Setting Programs



- **Netherlands**
 - 20% energy efficiency improvement by 2000 (1989 baseline)
 - Long-Term Agreements: contracts between the Dutch Minister for Economic Affairs and associations representing 29 industrial sectors (1250 firms) representing 90% of industrial energy consumption
- **U.K.**
 - 20% CO2 emissions reduction by 2010 (1990 baseline)
 - Climate Change Agreements: Government signed agreements with either industrial sector associations or individual companies representing 44 sectors (about 5,000 companies and 10,000 facilities) responsible for 90% of energy-intensive industry
- **China**
 - 20% reduction of energy use per unit of GDP by 2010 (2005 baseline)
 - Top-1000 Energy-Consuming Enterprises: contracts between Provincial governments and 1000 enterprises representing 48% of industrial energy consumption and 30% of total energy consumption in China

Industrial Sectors in Target-Setting Programs

U.K. Climate Change Agreements	Netherlands Long-Term Agreements	China Top-1000 Program
Cement	Cement	Construction materials
Iron and steel	Iron and steel	Iron and steel
Chemicals	Chemicals	Chemicals
Aluminium	Non-ferrous metals	Non-ferrous metals
Paper	Paper	Paper
Textiles	Textiles	Textiles
Glass	Glass	
Rubber	Rubber processing	
Brewing	Beer breweries	
Lime	Plastics	Coal mining
Semiconductors	Dairy	Petroleum/petrochemicals
Foundries	Sugar	Electric power
Plus 30 more sectors...	Plus 17 more sectors...	

Netherlands Long-Term Agreements on Energy Efficiency

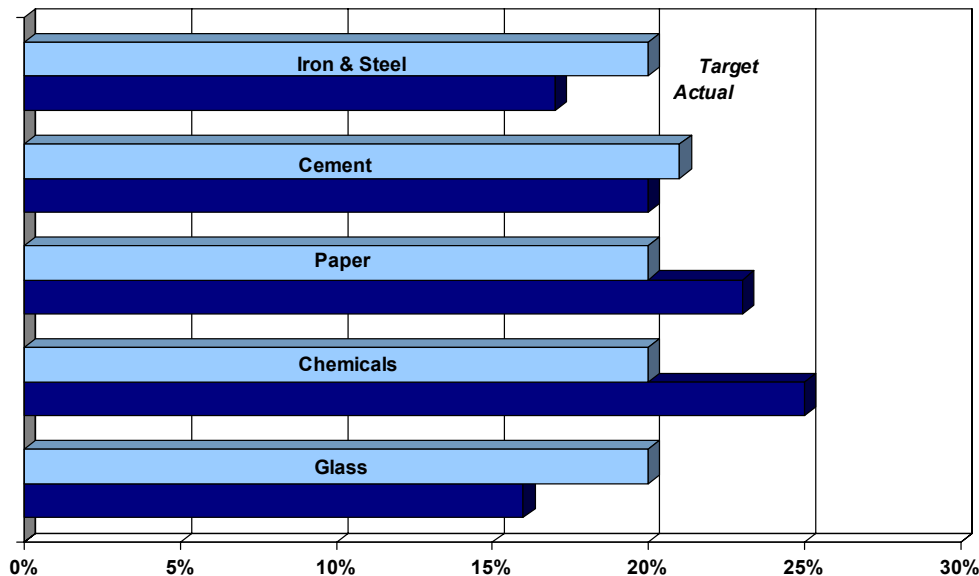
Goal: increase industrial energy efficiency by 20% between 1989 and 2000

- Novem approached industry sector, signed letter of intent
- Inventory of viable energy-efficiency improvement measures
- Target-setting agreement signed
- Energy Saving Plan developed
- Annual monitoring

Supporting Policies and Programs

- Subsidies
- Energy investment tax reduction
- Information dissemination and audit of facilities
- Simplified procedure for environmental permits
- Consistency in and protection from new energy regulation in industry

Netherlands Long-Term Agreements on Energy Efficiency



% improvement in energy efficiency, 1989-2000

Results:

- Overall energy efficiency savings of 22.3% realized
- 157 PJ or 9 MtCO₂/year saved
- 1/3 to 1/2 of the savings stimulated by the agreements (remainder was autonomous)
- Cost to government of program was \$10-20/tCO₂ saved, depending upon whether full costs of all subsidies are included
- Industry realizing ~\$650 M per year in reduced energy costs

UK Climate Change Agreements

Goal: Carbon savings of 9.2 MtCO₂ between 2000 and 2010

- Climate Change Levy: tax on energy (natural gas, coal, LPG, electricity)
- Companies that agree to and achieve GHG emissions reduction targets receive an 80% Climate Change Levy discount
- Company that does not enter into an agreement that does not reach its target, must pay 100% of the energy tax

Supporting Policies and Programs

- Carbon Trust: an independent body to promote carbon reductions in industry and commerce, advises industry through site visits, provides information and low costs loans for energy efficiency projects
- Enhanced Capital Allowance Scheme: Business can claim 100% tax allowances on their capital spending on energy saving equipment (specified in a government list) against their taxable profits for the year during which they make the investment
- Domestic Emissions Trading Scheme
- “Light Touch” on energy efficiency regulation

UK Climate Change Agreements

Results:

- 2001-2002: reductions of 16.4 MtCO₂
- 2003-2004: reductions of 14.4 MtCO₂
- Sectors did better than expected because industry underestimated what they could achieve via energy efficiency
- Industry is saving over \$832 M/year on the energy it has not bought as a result of meeting the CCA targets, in addition to the savings on the Climate Change Levy itself



Conclusions

- **No “silver bullet”** – there are hundreds of emission reduction technologies and measures for industry
- **Implementation of mitigation measures is key issue** – industry excels at producing specific commodities, not at saving energy or reducing GHG emissions
- **Target-setting can provide motivation** - experience from other countries and companies shows that target-setting with explicit commitments can result in significant savings
- **Supporting policies and programs are essential** - comprehensive programs are needed to assist industries in reaching their goals

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